Siblings' Impact on Caregiver-Infant Interactions and its Relationship with Language Outcomes

Research Thesis

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by

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ABSTRACT

Objectives: Child early language environment is a critical factor in children's language development and future achievement. This thesis explored whether birth order affects one aspect of language environment, namely parent-child interaction, and language development in children with hearing loss as compared with children with normal hearing (NH).

Design: LENA software recorded the participants' daylong natural language environment and automated the conversational turn count per hour. A total of 19 children with cochlear implants (CIs), 17 children with hearing aids (HAs), and 36 NH peers participated in our study. Expressive vocabulary was measured by The MacArthur-Bates Communicative Development Inventory (MCDI) Words and Sentences test. Participants were separated into two groups (Firstborn and last-born) based on their birth order. Firstborns are the oldest or only child and last-borns are the youngest child in the family.

Results: Findings showed that CI last-borns had received a greater number of conversational turns than their firstborn counterparts, in contrast to firstborn HA participants having a larger exposure of conversational turns. NH firstborns and last-borns received similar numbers of conversational turns. Moreover, findings revealed firstborn HA and NH children had higher language outcome scores, compared to their younger siblings. While CI children had similar scores.

Conclusions: Future research and a larger sample size is needed to confirm this study's preliminary evidence, suggesting birth order affects parent-child interactions and language outcomes in children with hearing loss. These findings may inform early intervention programs to educate parents to be mindful to expose all of their children, regardless of age and birth order, with comparable input.

Keywords: parent-child interaction, children, cochlear implants, hearing aids, conversational turns

INTRODUCTION

Increasing advancements in technology and greater accessibility to hearing devices has led children with Hearing Loss (HL) to access greater opportunities to acquire spoken language. For children diagnosed with severe to profound hearing loss, families have historically struggled to communicate with their children, as data has shown that more than 90% of deaf children have hearing parents (Mitchell & Karchmer, 2002). Consequently, this high percentage indicates that most caregivers' first language is orally produced. Learning a sign language like American Sign Language may not be effective because this creates an obstacle as parents are learning another language while trying to effectively provide their child with a proficient language environment. Hearing devices like Hearing Aids (HAs) and Cochlear Implants (CIs) give the opportunity for children with HL to have access to an oral-language learning environment that decades ago was not available.

However, while some children with HL will perform at the similar academic level of their peers, most have deviations and delays in their language and speech outcomes (Geers et al. 2011; Holt et al., 2012; Sarant, Holt, Dowell, Richards & Blamey, 2009). HL children’s language outcomes are cause for concern because poor language skills can lead to a variety of problems including: underachievement academically, behavioral, personal, societal, or even economic hardships (Mohr et al., 2000). One important factor that is related to children’s language development is early language input, especially the interaction between the caregivers and their child. Research across the decades has determined the important relationship between the caregiver input and caregiver-child interactions and speech, language, and cognitive development (Hart & Risley, 1995; Newman et al, 2016; Thiessen & Saffran, 2003; Papousek, 1991; Werker, Pegg &

MCLeod, 1989; Weisleder & Fernald, 2013). Input may be particularly important for children with HL because of a period of auditory deprivation before receiving devices. Caregiver input to a child may be affected by many factors, including whether the child has siblings, which in turn may affect child language outcomes. The goal of this thesis was to examine the effects of sibling on parent-child interactions and language outcomes in children with HL and children with normal hearing (NH).

Parent-child interactions and its Influence on Normal Hearing Children's Language Development

In 1995, Todd Risley & Betty Hart (1995) found groundbreaking results from their longitudinal study researching whether caregiver input or infant directed speech (IDS) has the greatest impact on a child's academic and language abilities. This longitudinal study examined the lives of 42 families from different socioeconomic statuses. They collected natural in-home interactions between parents and their child once each month for two and half years. They transcribed every word spoken to children ranging in ages from 7 to 36 months for an hour a month to have a greater insight on the child's real language environment. The researchers found that the quantity of caregiver talk was a significant predictor of child language and cognitive outcomes. Researchers also found data supporting that children have the ability to overcome their disadvantages and uncontrollable factors, such as low socioeconomic status, if their language environment is filled with rich and meaningful utterances. Later success was found to be linked to the amount of caregiver speech children heard during their critical language period of birth to three years (Gilkerson & Richards, 2009; Risley, 2006).

Subsequent research extended Hart and Risley's (1995) work and examined the relationship between parent-child interactions and language outcomes. This body of research has shown that parent-child interactions play an important role in language development. A recent meta-analysis examined the impact of mother-infant relationships and various factors that influence the development of the infant (Rocha et al., 2020). They found a significant positive correlation between infant development and maternal sensitivity, responsiveness, and verbal stimulation influencing an infant's language. Specifically, these studies had consistent results in showing positive caregiver response was correlated with better expressive language, receptive language, and word imitation (Nicely et al., 1999; Rocha et al.; 2020; Sansavini et al., 2015; Soares et al., 2018; Tamis-LeMonda et al., 2001; Wallace et al., 1998;). Rowe (2012) examined the complexity of the parents' language to see if this was a reasoning behind the child's vocabulary lexicon, instead of the quantity of IDS around the children. This study found data, standardized testing measures PPVT scores, to support earlier claims that parent input, correlated to receptive vocabulary growth (Hoff, 2003; Rowe, 2012). Similarly, children reported having greater language outcomes and consonant-vowel vocalizations (CVV) when the child's vocalizations received more contingent responses from their caregivers (Gros-Louis, West, & King, 2014). With the advancement of automated speech technology, new tools allow for automated speech analysis generating faster, more efficient processes of analyzing the childrens' audio recordings.

IDS, especially conversational turns (CTs) between parents and the child, are necessary as there is support for a relationship between prelingual CTs and a child's language acquisition (Levinson, 2016). Romeo et al (2018) demonstrated similar results in a population of older children. The study had 36 audio recordings of children aged 4 to 6 years old, and found greater conversational turns attributed to greater activation in Broca's area, during language processing. Supporting research above emphasizes the importance of parent-child interactions to children with normal hearing's language development.

However, the quantity and quality of parent-child interactions may be affected by many factors, including birth order. According to the *resource- dilution model*, children with more siblings are negatively impacted by the division of resources between siblings (Blake, 1981). Blake found, even from high socioeconomic families, negative consequences of less academic encouragement are still present because of a large family size. Across well-off socioeconomic families, the *resource- dilution model* displays the maximum resources a family has. Even if parents want to give each of their children equal attention, if it is an unrealistic task, as there is not an infinite amount of caregiver input they can give to their children. Do parents unintentionally decide who receives more input, or are there natural factors like birth order that determine this?

Numerous studies examining birth order suggest parents use more responsive language towards their oldest child, leading their youngest child to have different linguistic input (Gilkerson & Richards, 2009; Jones & Adamson, 1987; Woollett, 1986). In the "Power of Talk," Gilkerson & Richards (2009) continue to discuss the effect of birth order. Firstborns had a higher exposure to adult word count as data showed their language environment was filled with an average of 1,338 more words per day (Gilkerson & Richards, 2009). Anne Woollett (1986) calculated the Mean Length Utterance (MLU) of mothers and found data that showed a lower number and length of utterances directed at the youngest sibling. Once the firstborn child and caregiver were in the presence of the younger children, this led both adult and child to use shorter utterances (Woollett, 1986). One of the key findings from Hart & Risley (1995) showed that parents talked less to their children with normal hearing if they were not as advanced linguistically (Gilkerson & Richards, 2009). Parents might feel quick to judge the linguistic abilities of their children and unintentionally give them less input. This could lead to a child having access to less input and ultimately impacting their future language and academic outcomes.

A few studies have shown that last-born children have lower language outcomes compared to their older siblings (Black et al., 2005; Fenson et al., 1994; Jones & Adamson, 1987). For example, Fenson et al. (1994) conducted a large study including children 8 to 30 months old and assessed their language outcomes from the MacArthur-Bates Communicative Development Inventory (MCDI) test. They found that later borns are at a slight disadvantage for word production and gesture production in the infant group; a small negative correlation of word production, word combination, and MLU for their toddler participant group (Fenson et al., 1994). Language outcomes were similar to educational outcomes, as firstborns had higher testing scores (Black et al., 2005; Kantarevic & Mechoulan, 2006). From the previous data, firstborn children or firstborns have greater access to caregiver input, leading to greater educational and language outcomes.

The Impact of Parent-child Interactions in Language Development in Children with Hearing Loss

Although there is limited research on children with HL, there are studies showing a relationship between caregiver-child interactions and language outcomes, specifically maternal sensitivity (Quittner et al., 2013; Spencer & Meadow-Orlans, 1996; Pressman et al, 1999) and maternal lexical repetition properties (Wang et al., 2020). Quittner et al. (2013) examined the relationship between maternal sensitivity, i.e., the mother's responsiveness to the child, and language growth for CI children. They found that children with CIs had a smaller language delay of 1.3 years when their parents exhibited higher maternal sensitivity measured by videotaped tasks in comparison to a language delay of 2.7 years for CI children whose parents exhibited a lower maternal sensitivity (Quittner et al, 2013). As higher maternal sensitivity narrowed the language delay for CI children from 2.7 years down to 1.3 years, they emphasized the important role of parent behaviors as a tool for intervention. The findings for age at implantation were just as critical

(Quittner et al., 2013). Wang et al. (2020) found CI infants were exposed to comparable lexical repetition properties as their NH peers. Also, subsequent language skills had a correlation with maternal lexical repetition measures (Wang et al., 2020). Moreover, in Dilley et al. 's (2020) study, they looked at the quality, e.g., speech rate, F0, and vowel formant measures, and quantity, amount or variation, of IDS and found the differences of maternal speech correlated significantly to greater language outcomes of CI two years after implantation (Dilley et al., 2020). These results support the theory that the language environment fosters language outcome in children with CIs, just like children with NH (Dilley et al., 2020).

As research on the HL population is understudied, currently there is no research looking at the influence of the presence of siblings affecting caregiver interactions, specifically parent-child interaction. The current lack of research surrounding HL children is a driving factor leading this study. Based on previous research for children with NH, the existence of siblings can have a large impact on the attention another child receives from their parents since most HL children academically and linguistically do not match their chronological aged peers language skills (Geers et al. 2011; Holt et al., 2012; Houston & Bergeson, 2014). Finding more information on caregiver-child interactions in the home environment and factors influencing parent-child interactions would lead to greater knowledge on the language children with HL are exposed to. Since there is strong evidence that NH firstborn children have greater educational and language outcomes, it is crucial to look at how this affects firstborn and last-born children with HL. Furthermore, previous research has shown last-born children receive less parent attention and input (Gilkerson & Richards, 2009; Woollett, 1986; Jones & Adamson, 1987). Empirical evidence has discovered target maternal sensitivity and language to be a positive tool in intervention and even improved the language skills of a child (Landry, Guttentag, Smith, & Swank, 2008; Bornstein et al., 2020). Early intervention can be the tool to help identify parents with low maternal sensitivity or caregiver interactions and create a better language input environment for their HL child.

Current Study

This study examines how the presence of a sibling will impact parent-child interaction and language development for children with HL. To achieve the goals of the study, three groups: CI, HA, and NH were examined. Children with HAs were diagnosed with mild to moderate HL. In contrast, CI children were diagnosed with profound to severe HL and had to use HAs for a period of time before implantation. Within these three groups, the target child was identified as either the firstborn or last-born. The first aim of this study was to identify (1) how the existence of siblings could impact parent-child interactions in children with HL, as compared with NH children. Because of how parents interact with children based on their birth order, I do not believe there will be a difference with the child's exposure to input, across the different hearing status groups. Based on previous data on the effect of siblings on language outcomes and caregiver input, I predict the firstborn child will have the greatest caregiver input and conversational turns. The second aim was to explore (2) how sibling status may influence language development in children with HL, relative to children with NH. To address these questions, this study collected daylong audio recordings using the automated LENA system and examined language outcomes using the MacArthur-Bates Vocabulary Checklist (MCDI) (Fenson et al., 1994). It is hypothesized that language outcome measures and CTs will be consistently higher from the oldest child, regardless of hearing status.

METHODS AND MATERIALS

Participants

The data collected from the families and children who participated in this study originated from a longitudinal investigation focusing on the language development and environment of children with hearing loss. A total of 72 children (40 females, 32 males) and families met the inclusion criteria for this study. All of the families were from the Midwestern region of the United States. The cohort of children ranges from ages 5.85 to 33.55 months at the age of LENA recording.

An important foundation for this study was to include the participants in groups based off of their birth order. Only children and firstborns were grouped together as they are the firstborn children and have the same role in the family based on caregiver attention. Last-born children were defined as the youngest child of the family, at least one sibling was older than them. Participants with both older and younger siblings were excluded in the study and analysis due to the restraint of the limited number of participants. Each family included in this research project had a maximum of 4 children; the target child having no more than three additional siblings. Additional group characteristics of the children with HL and the children with NH grouped by birth order, are shown in Table 1.

Children with Hearing Loss

The criteria for the inclusion of children with hearing loss was based on whether the child had a diagnosis of a bilateral sensorineural hearing loss, mixed hearing loss, or Auditory Neuropathy Spectrum Disorder. Any presence of another diagnosis, including various language or cognitive impairments, excluded the child. It was required for the hearing loss child to use hearing technology of a cochlear implant or hearing aid that had been activated before 24 months of age. Families had to have English as their primary language in the home and spoken language as a goal but were not restricted on using different languages or language modalities. The majority of the participants with HL were recruited from Nationwide Children’s Hospital, located in Columbus, Ohio. The remaining children came from neighboring states.

Within the group of CI children participating in the longitudinal study, 19 fit the requirements of this study. There were 12 families that solely communicated with spoken English, five families used both spoken English and American Sign Language, and two families used spoken English and Sign Support. There were 17 HA participants who were eligible for this project. 12 families communicated only with English, 3 used both spoken English and American Sign Language, one family communicated with spoken English and Sign Support, and one spoke English and Arabic in the home.

Children with Normal Hearing

The 36 children with NH had typical development and no known history of language or hearing impairment participated in the study.

The recruitment, strategy, materials, and the study protocol were approved by the Ohio State University Institutional Review Board. Experimenters informed caregivers of the broad interests and potential (minimal) risks of the study during the consenting process. The participants from the longitudinal study would complete visits every three months based on either hearing age or chronological age. The goal was to collect an MCDI at every visit to see the infants' language development. Additional group characteristics for the children with HL and the children with NH are shown in Table 1.

Measuring quantity of parent-child interactions

The natural language environment of each participant was collected through the Language ENvironment Analysis (LENA) device (Gilkerson et al., 2018; Xu et al., 2008). A child's natural language environment is their home where the majority of conversation takes place. Because of LENA technology, researchers can record the child's natural interactions with caregivers and how caregivers interact with their children. The LENA system is a small device that is placed into a vest worn by the child (Gilkerson & Richards, 2009). The child wears this device all day and the LENA system is capable of recording up to 16 hours of language interactions per day (Gilkerson et al. 2018; Xu, 2008). Once the recordings are complete, the LENA system is then sent back to The BabyTalk Research Lab and the audio files are automatically processed. Each time a child used the device, the family would fill out a LENA assessment log, which gave information about the setting, people, and day.

Families contributed 1 to 3 recordings every three months for approximately one year. 295 recordings were included in the current analyses. The age at recording ranged between 5.58 to 38.55 months (*M* = 17.28 , *SD* = 6.90); the duration of the recordings ranged from 8.10 to 16 hours (*M* = 14.37, *SD* = 2.21).

We extracted the measures of parent-child interaction, specifically, conversational turns (CTs). CTs is the total number of conversational interactions between the target child and the caregivers in which one speaker initiates and the other responds within five seconds (Gilkerson & Richards, 2009). Because the duration of recordings varied, we normalized the CTs by the recording duration, resulting in CTs per hour. Descriptive characteristics of the recordings and measures of CTs separated by group and birth order are shown in Table 3.

Measuring Expressive Vocabulary by MCDI

The MCDI test (Fenson et al.,1994), was administered to assess participant language development. 34 participants completed the Words and Sentences (WS) version of the test (MCDI-WS). The MCDI-WS version is a 680-total assessment for children ages 16 to 30 months (Fenson et. al., 2000). Descriptive statistics of WS separated by group and birth order are provided in Table 2.

RESULTS

Descriptive Analysis

The descriptive analysis conducted on CTs and children's language outcomes were based on their respective hearing status and birth order. We also conducted independent t-tests to compare the measures of CTs and MCDI between the firstborn and last-born children.

Conversational Turns

CI children, on average, were exposed to approximately 37 conversation turns per hour. See Table 1 for additional demographics and audiological information across all groups. An independent sample t- test was used to test whether the firstborn sibling received more CTs than the last-born child. Results based on p values suggest that there were no significant differences between the firstborn and the last-born and this was consistent for all three groups, CI group: $t(17)= 1.40$, $p = 0.270$, $d = 0.52$; HA group: $t(14)= -0.877$, $p = 0.395$, $d = 0.49$; NH group: $t(34) = -0.045$, $p= 0.964$, $d = 0.02$. However, cohen's d showed medium effects for the CI and the HA groups. Last-born CI children averaged about ten more CTs per hour than the firstborn CI participants (CI: firstborn M= 33.99, SD=16.27; last-born M= 43.37, SD= 19.54). In contrast, the HA groups' averaged around 33 conversational turns per hour. Firstborn HA childrens' data was similar to previous findings on NH firstborn children limiting caregiver-interactions between last-born children (HA: firstborn M= 37.67, SD= 16.90 ; last-born M= 29.79, SD= 18.97). NH children had relatively no variation between their averages of 37 conversational turns per hour (NH: firstborn M= 37.54, SD= 28.50; last-born M= 37.16, SD= 16.60), see Figure 1.

Language Outcomes

Means and standard deviations are shown in Table 2 for participants' scores on the MCDI-WS tests. All the firstborn participants had higher average language expressive and receptive scores (CI: firstborn M= 380.57, SD= 215.20 ; last-born; M= 368.00, SD: 315.07, HA: firstborn M: 233.65, SD= 130.98; last-born M= 166.00, SD= 125.86; NH; firstborn M= 320.90, SD= 208.98; last-born M=211.00, SD= 151.14). However, independent sample t-tests based on p values showed that there were no significant differences between the first and last-born children across the three groups. CI group: $t(7)= -0.072$, $p= .945$, $d = 0.04$; HA group: $t(5)= .622$, $p=0.561$, $d = 0.52$; NH group: $t(16)= -1.20$, $p= .247$, $d = 0.60$. However, cohen's d showed medium effects for the NH and HA groups, because firstborns had larger vocabulary than last-borns.

Table 1.

Demographic and Audiologic Data (Mean, Standard deviation) for the participants, separated by hearing status (NH, CI, HA), and birth order

Variable	CI *(n= 19)*	HA *(n=17)*	NH *(n= 36)*
	mean(SD)	mean(SD)	mean(SD)
Firstborns	11	9	22
Female	7	6	17
Maternal education (years)	14.09(3.72)	17.89(2.08)	17.50(2.17)
Age at device fitting (months)	14.45(4.64)	16.36(3.91)	NA
Hearing Age (months)	8.81(5.61)	9.52(1.84)	14.52(6.60)
Chronological Age	23.26(7.27)	16.36(3.91)	14.52(6.60)
PTA (dB. HL)	62	61	NA
File Duration (hours)	14.33(2.28)	14.96(1.66)	14.12(2.38)
CTC (per hour)	33.99(16.27)	37.67(16.90)	37.54(28.50)
Last-Borns	8	8	14
Female	2	4	7
Maternal education (years)	14.75(2.60)	15.63(1.68)	15.50(1.91)
Age at device fitting(months)	13.09(3.21)	7.98(7.66)	NA
Hearing Age (months)	7.80(5.75)	9.02(3.32)	15.52(6.19)
Chronological Age	20.95(6.27)	17.01(6.65)	15.52(6.19)
PTA (dB. HL)	58	49	NA
File Duration (hours)	14.33(2.28)	14.96(1.66)	14.12(2.38)
CTC (per hour)	43.37(19.54)	29.79(18.97)	37.16(16.60)

Note. CI: cochlear implant; HA: hearing aid; NH: normal hearing; CTC: conversational turn count; PTA: amount of residual hearing measured by pure-tone average.

Table 2.

Descriptive Data on the Communication Outcomes of Participants

Variable	n	M	SD
CI			
Firstborns	6		
MCDI-WS		380.57	215.20
Age of MCDI-WS (months)		32.84	8.42
Last-Borns	3		
MCDI-WS		368.00	315.07
Age of MCDI-WS (months)		35.26	6.49
HA			
Firstborns	5		
MCDI-WS		233.65	130.98
Age of MCDI-WS (months)		25.92	7.80
Last-Borns	2		
MCDI-WS		166.00	125.86
Age of MCDI-WS (months)		14.44	11.64
NH			
Firstborns	11		
MCDI-WS		320.90	208.98
Age of MCDI-WS (months)		20.64	9.54
Last-Borns	7		
MCDI-WS		211.00	151.14
Age of MCDI-WS (months)		20.91	3.62

Note. CI: cochlear implant; HA: hearing aid; NH: normal hearing; MCDI-WS: The MacArthur-Bates Communicative Development Inventory Words and Sentences version

Figure 1.

Conversational Turns represented in M and SD, Separated by Birth Status

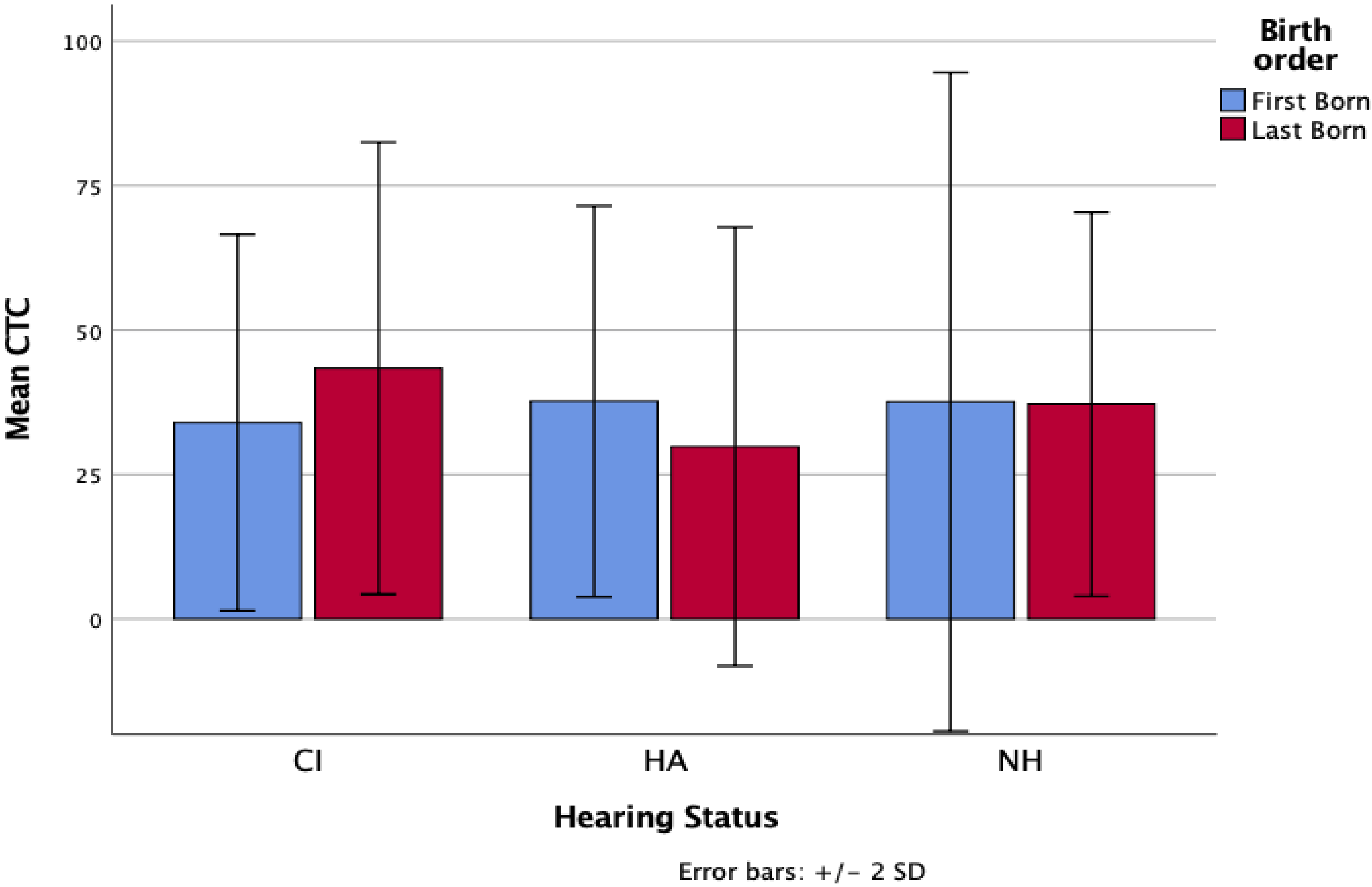
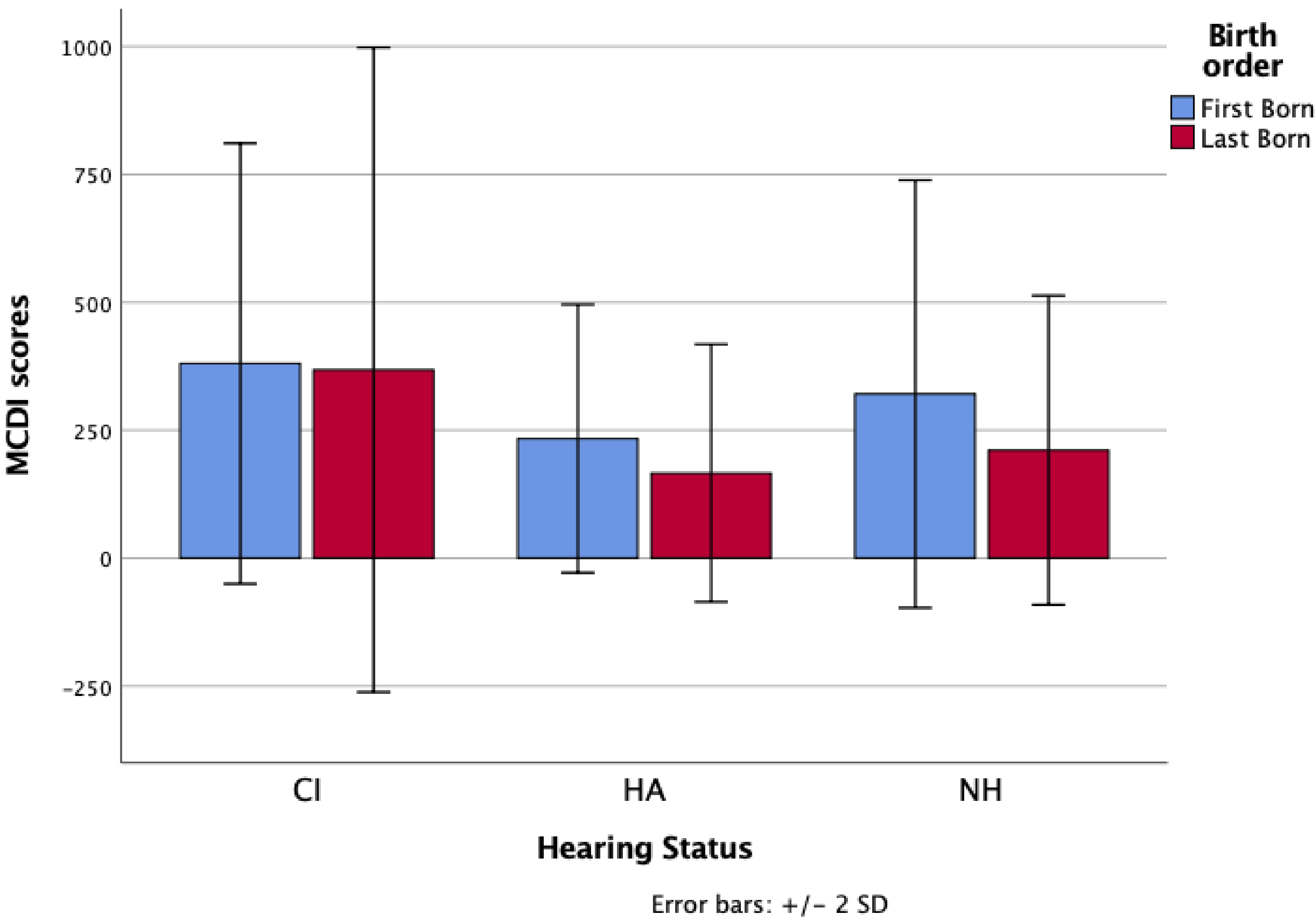


Figure 2.

Language Outcomes from MCDI-WS tests represented in M and SD, Separated by Birth Order



DISCUSSION

As a result of previous investigations identifying the role of birth order and the effect of siblings on caregiver-input, this study examined the effect of birth order on parent-child interactions and language outcomes in children with HL as compared to children with NH. Based on the competitive hypothesis of the *dilution model* discussed in Blake (1981), parents do not have an unlimited amount of resources, especially input and attention to give each child. Parents of children with HL have to deal with additional factors in comparison to families with NH, potentially resulting in reduced quantity of parent-child interactions. To answer these questions, we collected daylong recordings of natural parent-child interactions and as well as language outcomes from three groups of children: children with NH, children with CIs, and children with HAs. Suggested by the p-values, this study's findings would most likely be different with more added subjects. If more subjects were added and showed the same pattern, but more stable, then this would support a relationship between birth order and caregiver input and language outcomes. Due to the small sample size, our discussion will be based on the effect sizes.

For CTs, it was hypothesized that firstborn children, across all three groups, would be exposed to a greater number of CTs. Our data showed contrasting findings among the three groups. Specifically, for children with CIs, on average firstborn children received fewer CTs compared to the last-born children. HA firstborn participants received a larger number of CTs compared to the last-born HA children. Lastly, NH had no difference between the average number of CTs they were exposed to.

The results of this study indicate MCDI-WS tests scores were similar to previous studies reporting language outcomes based on the presence of siblings (Black et al., 2005; Fenson et al., 1994; Jones & Adamson, 1987). Original predictions favored the firstborn children across all three groups having greater language outcomes. Based on effect size, the data revealed that firstborn HA and NH children had larger MCDI scores. However, there were no large differences found for CI children. These results support the firstborn child's ability to achieve better expressive and lexical skills (Pine, 1995). Even though the results are not statistically significant, the data suggests there could be a potential association based on the presence of siblings having a negative effect on last-born children with hearing loss. CI children's findings are expected and there are several potential explanations.

One potential explanation for the results of last-born CI participants' higher CTs is the strengths each sibling has based on their birth order. As previously stated, firstborn siblings have higher language outcomes and expressive language (Black et al., 2005; Fenson et al., 1994; Jones & Adamson, 1987). On the other hand, later born children were found to have better conversational skill (Hoff-Ginsberg, 1998). In a study conducted on older children with HL, Most et al (2010) found CI children have difficulties with contingency between their conversational partner. If firstborn children potentially struggle with this pragmatic skill, this could lead to parents becoming discouraged. Parents are found to be more engaged in conversations with advanced children (Hart & Risley, 1995). If caregivers do not feel their children to be advanced, this could lead to decreased input. Last-born CI children conversational skills could give the potential to have greater access to CTs, compared to firstborn CI children.

Last-born CI children could have greater CT exposure as a result of parent stress and their parents experience with children. Parents deal with many difficult situations but having a hearing loss diagnosis could have a monumental negative effect on families. Parents of children with HL have more medical appointments and bills, increased appointments including therapies, ensuring the hearing technology is working properly, and worrying about their child's education and future endeavors. Sarant and Garrad (2013) examined stress on parents of children with HL and found parents had higher levels of stress when children had a language delay. Findings and previous research have shown that the HL parent population did have stress surpassing NH parents (Quittner, Julie & Rouiller, 1991; Sarant & Garrad, 2013; Spahn et al., 2001). Maternal education could impact the amount of language exposure to a child. Figure 1 showed CI children's average years of their mother's education to be m=14.09, SD= 3.72. In contrast, the average for the other groups was significantly higher (HA group was m= 17.89, SD= 2.08; NH group m=17.50, SD=2.17). In addition to this, many parents may accept a gesture or sign as a response instead of a verbalization (Huttenlocher et al., 2002). LENA technology would not be able to register this as CT, but the child could have made the response to the caregiver input. This could account for the firstborn CI participants having lower number of exposure to CT. Lastly, Parents are more knowledgeable when they have their second or third child, compared to their first. This experience could better prepare parents generating a rich language filled environment, regardless of their child's hearing status.

Most et al (2010) found results indicating children with CIs had similar results to HA participants, both struggling with the linguistic skill of contingency between a conversational partner. The HA participants were diagnosed with severe HL. A possible reasoning for this study's firstborn HA participants having higher exposure of CTs could be because the HA participants were diagnosed with mild to moderate HL. Their higher amount of residual hearing could lead them to potentially not struggle with contingency. Then, parents would not be discouraged and continue conversations and lead to greater input. This would indicate the varying results between the CI and HA groups.

Cultural traditions could be a rationale for the firstborn children having higher language outcomes. In a South Korean study researching temperament for infants, Bornstein et al. (2015) looked at how sex, age, and birth order determined stability. Data displayed firstborns being more stable in a variety of conditions of temperament, as a result of the possibility that parents determine how to interact with children based on their birth order position. Our study looks at Midwestern families, but this is one factor to consider.

Clinical implications

All HL children enrolled in this study are participating in various interventions. There is the possibility that some families are receiving feedback on the quality and quantity of their input and improving it. Gilkerson & Richards (2009) noted from findings from Hart and Risley (1995), "Parents are quite variable in the day to day amount they talk to their children, but given the opportunity to receive feedback they are able to increase the amount of talk consistently" (p.3). This is the goal and hopefully these findings will contribute to Evidence-based practice to assist parents. If given direction by professionals, parents have the ability to improve their quality of input and expose their child to a more beneficial language environment.

Limitations

Although several factors were discussed regarding reasoning for the variation among the results, additional variables (e.g., maternal education, relationship between siblings, and SES) could be valuable. The reliability of this data is impacted because of the small sample size. Most HL studies have small sample sizes, but the data for language outcomes is particularly small. Also, LENA'S algorithm has some disparities in identifying speakers' age or gender (VanDam & Silbert, 2016; Xu, Yapanel, & Gray, 2009). LENA could categorize adult speech for the child's sibling if their speech was sophisticated enough. In addition to this, because of the small sample size, the study was unable to examine a correlation between CTs and language outcomes. Further research is needed to address how children with HL are impacted by the presence of siblings.

CONCLUSION

In summary, the findings from this study suggest the possibility that birth order affects parent-child interactions and language outcomes in children with HL. We found that firstborn children could have better language outcomes as a result of their birth order. Last-born CI children were not disadvantaged in relation to their caregiver input for this study. HA firstborn children had the strongest language outcomes and numbers of CTs. In the future, larger sample sizes and more research will give greater insight into a potential relationship between siblings and its influence on caregiver input and language outcomes. These conclusions encourage parents to surround their children with quality caregiver-input and reliable early intervention programs.

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